

# (12) UK Patent Application (19) GB (11) 2 313 981 (13) A

(43) Date of A Publication 10.12.1997

(21) Application No 9705123.9

(22) Date of Filing 12.03.1997

(30) Priority Data

(31) 9611830  
9613404

(32) 06.06.1996  
26.06.1996

(33) GB

(71) Applicant(s)

**Roke Manor Research Limited**

(Incorporated in the United Kingdom)

**Roke Manor, ROMSEY, Hampshire, SO51 0ZN,  
United Kingdom**

(72) Inventor(s)

**John Steven Cundall  
Walter Harold William Tuttlebee**

(74) Agent and/or Address for Service

**Derek Allen  
Siemens Group Services Limited,  
Intellectual Property Department, Roke Manor,  
Old Salisbury Lane, ROMSEY, Hampshire, SO51 0ZN,  
United Kingdom**

(51) INT CL<sup>6</sup>

H04Q 7/32, H04L 29/06, H04Q 7/22

(52) UK CL (Edition O)

H4L LDG  
U1S S2124

(56) Documents Cited

EP 0700225 A2 EP 0629071 A1 WO 95/34153 A1  
US 5537399 A

(58) Field of Search

UK CL (Edition O) H4L LDG LDIX LDSX, H4P PPEC  
INT CL<sup>6</sup> H04L 29/06, H04Q 7/20 7/22 7/32  
On-Line - WPI

## (54) High speed wireless internet connection for portable computers

(57) A wireless communications link for a portable computer 1, comprises a first communicator 3, operating in accordance with a relatively low bandwidth GSM based mobile radio telephone system such as DCS 1800 or PCS 1900, to provide a first digital communications channel 3a, a second communicator 2, operating in accordance with the higher bandwidth Digital Audio Broadcast (DAB) system, based on the Eureka-147 standard, to provide a second digital communications channel 2a, and a data processor unit 15, arranged to operate in combination with the first and the second communicators, which transmits the portable computer's data requests to the internet via the first communications channel 3a and receives internet data via the second communications channel 2a, thereby providing the portable computer with a low bit rate channel for communicating its limited instructions to an internet supplier and a high bit rate channel for downloading large data files from the supplier.

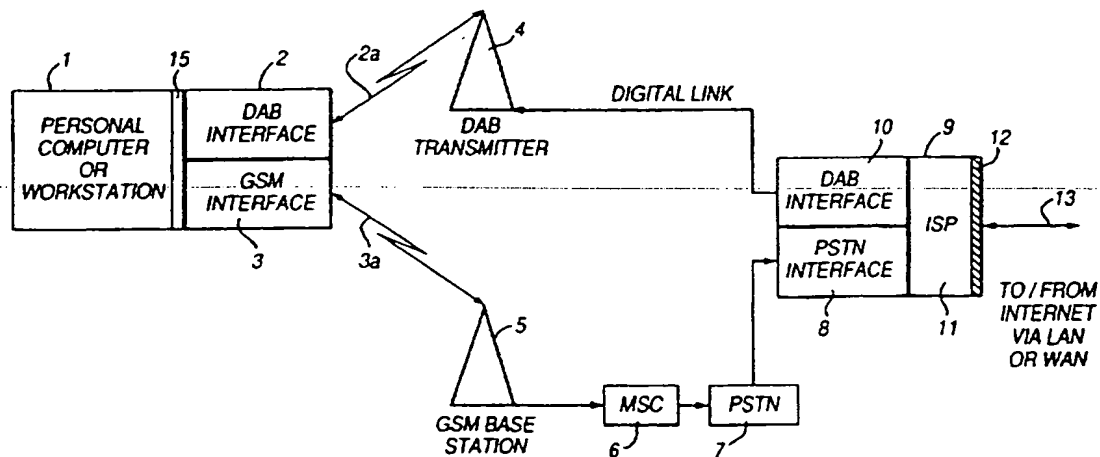


Fig. 1

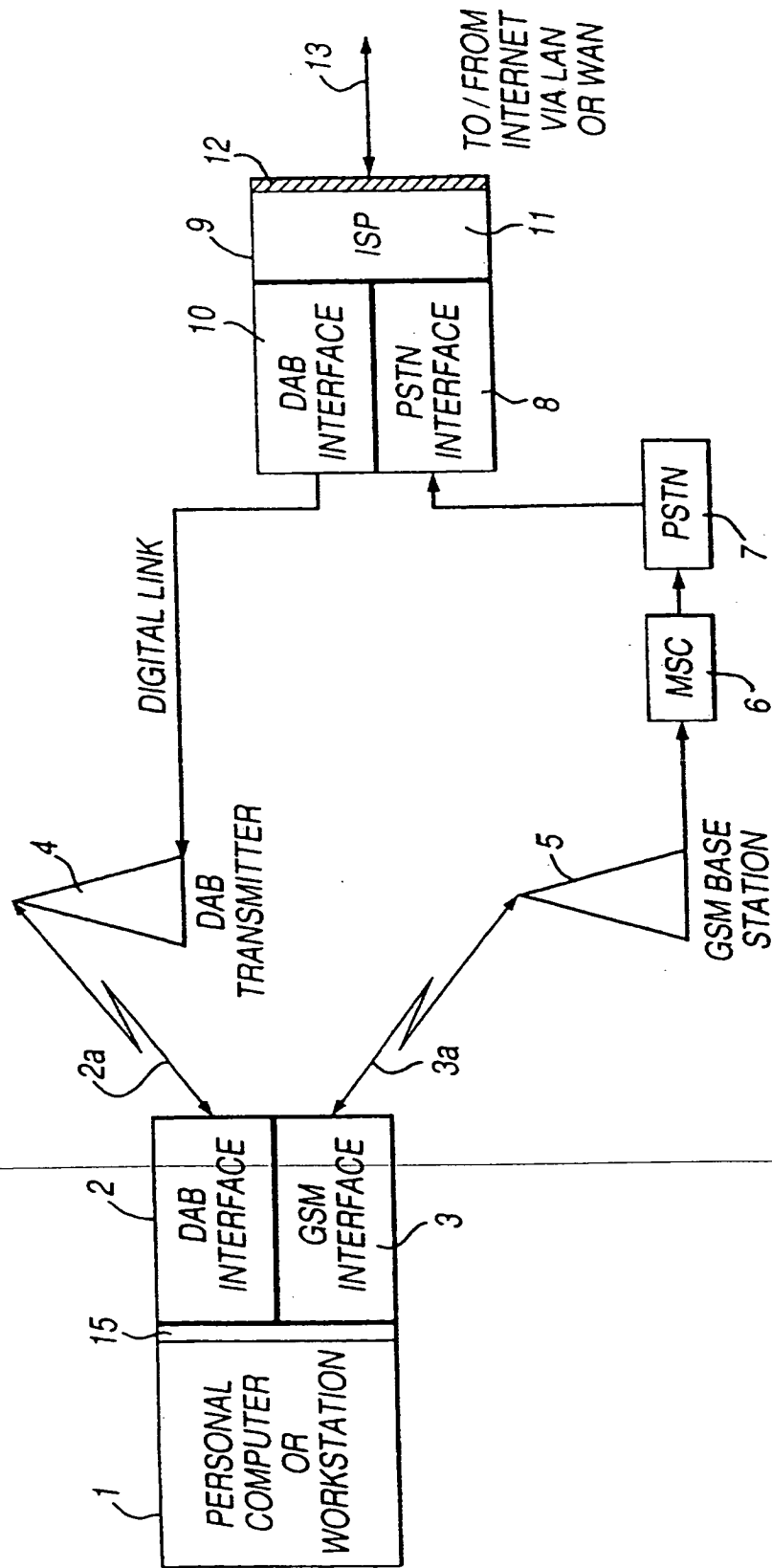


Fig. 1

2/2

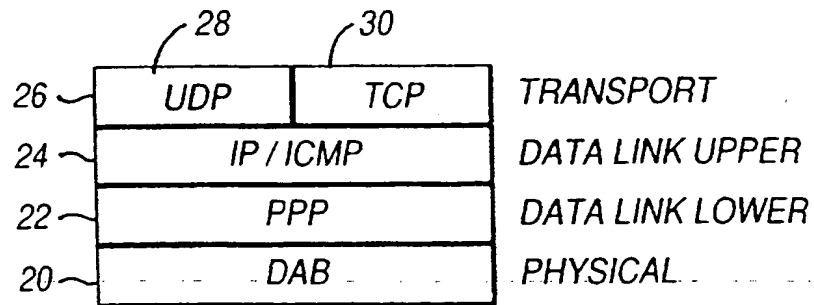


Fig. 2a

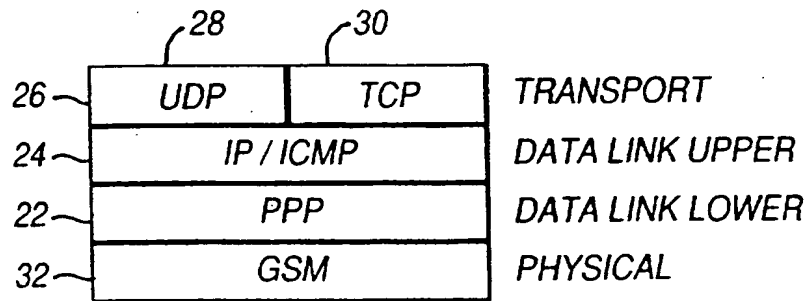


Fig. 2b

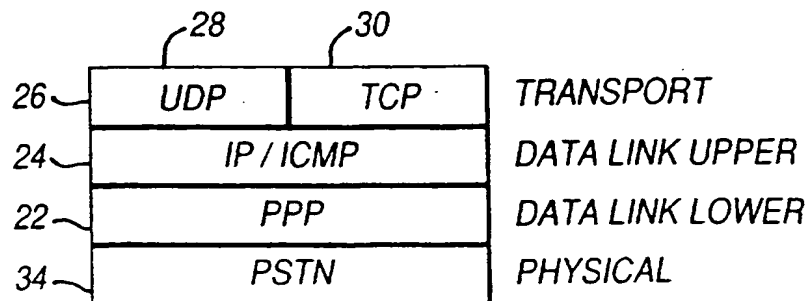


Fig. 2c

## IMPROVEMENTS IN OR RELATING TO PORTABLE COMPUTERS

The present invention relates to apparatus for providing wireless communications to portable computers and the like.

Wide area telecommunications networks provide a facility for effecting data communication between remotely located computers connected to the networks. By interconnecting a plurality of such wide area networks it is possible to create a combined telecommunications network through which computers distributed over a significant portion of the earth may be interconnected. Such an interconnection of networks is known as an internet, and serves to provide a computer connected to the internet with a facility for accessing information on other computers located in other parts of the world.

Portable computers or personal computers as they have become known have been developed in such a way that their size and weight are such that they may be easily transported and operated from any convenient location. However, heretofore, to establish a high data rate connection from a PC to an internet, has required the use of a modem connected to a fixed telecommunications network, inhibiting mobility.

It is an object of the present invention to provide a portable computer or the like with a wireless communication link to a telecommunications network.

According to the present invention there is provided apparatus for providing a wireless communications link to a

portable computer, comprising a first communicator which operates in accordance with a mobile radio telephone system to provide a first digital communications channel for substantially low data rate communications, a second communicator which operates in accordance with a Digital Audio Broadcast (DAB)-like system to provide a second digital communications channel and a first data processor unit which acts in combination with the first and the second communicators to communicate requests for data to an internet from the portable computer via the first communications channel and for the data to be communicated to the portable computer via the second communications channel, thereby providing the portable computer with an asymmetric wireless connection to the internet.

The first communicator may comprise first and second transmitter and receiver pairs, which operate to provide the portable computer with a means for duplex communications via the first communications channel with a mobile radio telecommunications network.

The second communicator may comprise a transmitter and a receiver, the receiver being embodied within the portable computer, so that said transmitter and said receiver in

---

combination operate in accordance with the DAB-like system to provide the second communications channel.

The second communications channel may be a simplex communications channel. The first data processor unit may be an applications program interface processor, which operates to

exchange data between applications programs operating on the portable computer and the first and second communicators.

Information exchanges on internets may be characterised in that data communication is somewhat asymmetric with regard to information transfer. This is because, typically only a small amount of information is sent from the personal computer requesting access to data, but a large amount of data is communicated back over the internet to the personal computer. This might be indicative of a situation where a large amount of information such as graphics or a database access is being communicated to the user of the personal computer.

By providing a portable computer with two communicators, a first of which operates to form a first communications link in accordance with the mobile radio system and a second of which operates to form a second communications link in accordance with the DAB-like system, the portable computer is provided with a low data rate channel for controlling access to the internet via the first communications link and with a high data rate link for receiving data from the internet via the second communications link.

The term 'portable computer' is intended to cover devices used to process or analyse data of which a personal computer is but one example. The term 'internet' is intended to encompass a plurality of interconnected telecommunications networks.

Advantageously the mobile radio system may be a cellular mobile radio system such as a Global System for Mobiles (GSM) - like system. The cellular mobile radio system may be a

CDMA system based on the IS-95 standard. The mobile radio system may be a cordless system such as a Digital Enhanced Cordless Telephone (DECT) system. The cordless system may be a Cordless Telephone 2 (CT2) system.

The Global System for Mobiles (GSM) is a digital mobile radio telephony standard administered by the European Telecommunications Standard Institute. The GSM standard provides a specification for manufacturing a digital time division multiplexed mobile radio telephone system. There are currently a plurality of mobile radio networks which have been fabricated and installed in various locations throughout the world in accordance with the GSM standard.

Digital Communications System (DCS) 1800 is a derivative of GSM in that the protocols and data format are substantially the same as for GSM, however the operating frequency is 1800 MHz as opposed to 900 MHz which is the case with GSM. As such DCS 1800 may be described as a 'GSM-like' standard. It is hereby stated that 'GSM-like' systems as referred to herein include all systems embodying derivatives and variations of the GSM standard whilst still falling within the general scope of the GSM standard as defined and administered by the European Telecommunications Standards Institute. A further example of a GSM-like system is PCS1900.

---

To provide the GSM mobile radio telephone system with a means for maximising a number of telephone calls that can be supported within a given radio frequency bandwidth and radio coverage area, the GSM system has been provided with a plurality

of low bit rate digital communications channels for use with correspondingly low bit rate speech codecs. A digital data communications channel allocated to a mobile is therefore characterised in that the communications channel has a relatively low bit rate, which is in the order of 9.6 kbit/s.

Similarly, other cellular mobile radio systems such as the IS-95 Code Division Multiple Access system are arranged to provide a plurality of low bit rate mobile radio digital communications channels, for data communications with mobile units. Such a system as with other cellular radio systems are characterised in that they are arranged to optimise as far as possible, a number of low bit rate duplex communications channel within an allocated radio frequency bandwidth and radio coverage area.

Cordless telephone systems, such as DECT are also arranged to provide a plurality of low bit rate duplex communications channels, albeit without a facility of full mobility afforded by cellular radio systems.

The Digital Audio Broadcast (DAB) system is a digital high fidelity broadcast system for music and other entertainment programmes and data services as defined in accordance with the Eureka-147 standard, administered by the European Telecommunications Standard Institute. DAB broadcasts are transmitted to users of the systems which are provided with appropriate receivers to recover data representative of sound and music. As a result of a requirement for high fidelity the DAB system is provided with a plurality of orthogonal radio frequency carrier signals which are arranged to be contemporaneously



modulated with data communicated by the system. This modulation arrangement, which is known as Orthogonal Frequency Division Modulation (OFDM), affords a facility for particularly high data rate communications which is sufficient to communicate high fidelity programmes in real time. Furthermore, infrastructure, required to provide broadcast programmes for users using DAB receivers, is arranged to facilitate radio reception at remote locations covering a substantial part of a continent or state. Therefore, by providing the high data rate communications channel using a DAB broadcast channel, economy of scale of mass produced DAB receivers and re-use of the DAB infrastructure, provides an inexpensive high data rate communications facility to a mobile terminal.

It is hereby stated that 'DAB- like' systems as referred to herein include all systems embodying derivatives and variations of the DAB Eureka-147 standard whilst still falling within a general scope of this standard as defined and administered the European Telecommunications Standards Institute.

One embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings wherein,

FIGURE 1 is a conceptual block diagram of a personal computer communicating with an internet via a wireless communications link and,

FIGURE 2a is a conceptual block diagram representing a stack of operating protocols for a DAB interface.

FIGURE 2b is a conceptual block diagram representing a stack of operating protocols for a GSM interface.

FIGURE 2c is a conceptual block diagram representing a stack of operating protocols for a PSTN interface.

A system which operates to provide a wireless communications links to a personal computer (PC) is shown in Figure 1. The system is comprised of a first link via a GSM system and a second link via a DAB system. In Figure 1, a PC 1, embodies a DAB interface unit 2, and a GSM interface unit 3. The DAB interface unit 2, is shown to receive information via a DAB transmitter 4, which in combination form a DAB communications channel 2a. The GSM interface unit 3 is shown to communicate information via a GSM base station 5 which in combination form a duplex communications channel 3a. The GSM base station 5, is connected to a mobile switching centre (MSC) 6, and is in turn connected to a public switch telephone network (PSTN) 7. The base station 5, MSC 6, and PSTN 7, are connected in accordance with a general architecture of the GSM system. The public switch telephone network 7, connects to a PSTN interface 8, of an interface unit 9. Also shown in the interface unit 9 is a DAB interface 10, and an Internet Service Provider (ISP) 11, which has an internet interface 12, to a local or wide area network (LAN or WAN) which forms part of the internet 13. The DAB transmitter 4, is connected to a DAB interface 10, via an appropriate communications link 14. In a more general embodiment, the PSTN may be replaced by a private fixed network, e.g. any

interconnection network belonging to or used by the mobile network operator or broadcaster.

The PC 1, is provided with the GSM interface unit 3, which operates in accordance with the GSM protocol to set up a digital communications link with a GSM base station 5. This link provides a low data rate duplex communications link 3a through which the PC may send access commands which are to be communicated to the internet. The GSM base station 5, is arranged to be connected via the MSC 6, and the public switch telecommunications network 7, to the PSTN interface 8, within the interface unit 9. This arrangement thereby provides a facility whereby commands generated within the PC to access the internet are communicated to the interface unit 9, via a GSM communications channel. Within the interface unit 9 the ISP 11, operates in combination with the internet interface unit 12, to communicate internet access commands to the internet 13. Information received from the internet in response to these access commands, is also conveyed via the interface 12.

Typically an access to the internet from a PC is characterised in that the information transferred to the PC, hereinafter referred to as the down stream direction, is much greater than that transferred from it, hereinafter referred to as the up stream direction, particularly where the PC is a portable or 'notebook' type PC. For this reason information is communicated down stream to the PC via the DAB system.

The Internet Service Provider (ISP) 11, is provided with a modem which operates to communicate data via the public switch

telephone network 7. Users of the system are provided with a telephone number of the modem so that they can dial up the Internet Service Provider to provide connection to the internet. The Internet Service Provider in a down stream direction acts as an interface to retrieve data arriving from the internet and passes this via the DAB interface 10, to the DAB transmitter 4. The DAB transmitter thereafter transmits information via a communications channel 2a, set up in accordance with the DAB standard to the DAB interface 2, within the PC 1. The DAB communications link is a simplex high capacity communications link thereby providing the system with a rapid and efficient transmission of digital information arriving over the internet down stream to the user of the PC 1.

The Internet Service Provider operates to provide a connection to the local or wide area networks forming part of the internet. The local area network connection may be an Ethernet interface or a Fibre Distributed Data Interchange interface whereas the wide area network may be a frame relay or X.25 connection. The ISP 9, provides an internet protocol routing function for the GSM or DAB users.

To provide the personal computer 1, with a means for communicating over the GSM and DAB links in combination with the DAB and GSM interface units, an Applications Program Interface (API) 15, is provided which operates to exchange data and commands between the personal computer 1, the DAB interface 2, and the GSM interface 3.

To provide a facility whereby data may be communicated from the personal computer to the ISP 9, within the interface unit 10, the interface units 2, 3, 8 and 10 are provided with a stack of layered interacting protocols, which are shown in Figure 2a, 2b and 2c.

In Figure 2a, a protocol stack for the two DAB interfaces 2, 10 of Figure 1, is shown to be comprised of several layers of operating protocols on top of a physical transport layer. A physical layer is shown to be comprised of the DAB physical layer which appears in layer 20. Communicating with the physical layer 20, is a lower data link layer 22, which operates to provide a point-to-point protocol. The lower data link layer 22, is connected to an upper data link layer 24, which operates an Internet Protocol (IP) as well as an Internet Control Message Protocol (ICMP) protocol. A transport layer 26, is connected to the IP/ICMP layers. The transport layer 26, is comprised of either a User Datagram Protocol (UDP) or a Transport Control Protocol (TCP). The TCP protocol may be used for connection oriented communications, whereas where appropriate the UDP protocol is provided for connection-less communications.

A protocol stack for the GSM interface 3, is shown in Figure 2b, where parts also appearing in Figure 2a bear identical numerical designations. Similarly a protocol stack for the PSTN interface 8, is shown in Figure 2c, where parts also appearing in Figures 2a and 2b bear identical numerical designations. In Figure 2b the protocol stack for the GSM interface differs from that of Figure 2a only in that the physical layer is comprised of a

GSM physical data transport apparatus 32. Correspondingly the protocol stack for the PSTN interface differs from Figure 2a and 2b only in that the physical transport layer is comprised of a PSTN physical transport layer 34. The operation of the protocol stacks shown in Figure 2a and 2b is otherwise substantially the same as that shown in Figure 2a, and therefore will not be repeated.

In each of the protocol stacks shown in Figure 2a, 2b and 2c the lower data link layer 22, is comprised of an internet standard 51 point-to-point protocol in accordance with RFC1332 IPCP (PPP Internet Protocol control protocol) hereafter referred to simply as PPP. The PPP is a known standard which defines a protocol which operates to establish and configure point-to-point communications links for carrying a variety of upper layer protocols, one such protocol commonly implemented is the Internet Protocol (IP) as defined in accordance with the known standard RFC 1332. The PPP protocol operates to establish a communications link between two entities during an establishment phase. For example, the PPP protocol operates to establish a link between the GSM interface 3, and the PSTN interface 8. The PPP link establishment phase has only a low data rate requirement and is conducted initially using only the GSM duplex link. Once the PPP link is established the DAB downlink is invoked, thereby allowing a higher rate downlink to be supported, i.e. an asymmetric data rate circuit between the PC and the ISP. Once this has happened the GSM Short Message Service (SMS) may be used as the low data information request channel up-link. Alternatively the GSM bearer channel may be retained, but this represents a less spectrally efficient solution.

Once the appropriate data links have been established the PPP may provide an optional authentication phase followed by a mandatory network layer protocol phase for the transportation of information packets between the PC and the ISP.

Establishment of an internet link can only be performed from the PC side by an initialisation means embodied therein. However, the PC may be remotely instructed via the GSM network to perform such a link establishment. Thus link initiation can be performed from the PC, from the ISP, or from a third party. This facility allows new services to be supported, e.g. scheduled delivery of e-mail.

During start up of the PC, when the PC 'boots', the IP layer 24, is initialised to use the PPP interface. However the PPP interface will not initiate the link to the ISP 9, until the user of the PC provides the necessary prompt. The PPP layer 22, provides either automatic IP number allocation, so that users of the PC will not have a fixed IP number but rather will be assigned an IP number as part of a PPP network layer protocol phase, or provides static IP number allocation, so that the PC will have a fixed IP number. IP routing tables communicating IP data will be provided with the default router to be set to interface in the ISP 9. The PPP implementation could automatically add and remove this route when the PPP link is established and disconnected. Also operating within the IP layer is an ICMP protocol. The ICMP protocol operates to exchange IP layer control messages which are carried within IP packets.

The internet protocol operates in accordance with the two higher layer protocols TCP, 20 and UDP 28. In conventional operation an internet protocol link to a PC is adapted for use with communications link providing symmetrical response times. However for operation with the wireless communications link as hereinbefore described, a response time in the down stream direction will be substantially shorter than that in the up stream direction. For this reason the TCP protocol, which is a connection oriented protocol may be adapted and arranged so that a requirement for an acknowledgement of a segment of data as provided in accordance with the Nagle algorithm in RFC 896 standard may be ignored. This is because the acknowledgements would be sent over the GSM link which is relatively slow, whereas data is transported over the relatively fast DAB link. Therefore by disengaging the Nagle algorithm, data transfer over the DAB link will not be substantially delayed as a result of a requirement to wait for acknowledgements over the relatively slow GSM link. This may be particularly important where the DAB transmitter is embodied within a satellite station so as to effect an increase in radio coverage. In this case further adaptation to the TCP protocol may be provided.

As will be appreciated by those skilled in the art various modifications may be made to the arrangements hereinbefore described without departing from the scope of the invention and for example, the invention may find application with other telecommunications systems wherein an asymmetric data flow facility is required. Furthermore an alternative high capacity



communications link may be provided instead of a DAB-like transmission link.

**CLAIMS:**

1. Apparatus for providing a wireless communications link to a portable computer, comprising a first communicator which operates in accordance with a mobile radio telephone system to provide a first digital communications channel, a second communicator which operates in accordance with a Digital Audio Broadcast (DAB)-like system to provide a second digital communications channel and a first data processor unit which acts in combination with the first and the second communicators to communicate requests for data to an internet from the portable computer via the first communications channel and for the data to be communicated to the portable computer via the second communications channel, thereby providing the portable computer with an asymmetric wireless connection to the internet.
2. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 1, wherein the first communicator comprises first and second transmitter and receiver pairs, which operate in accordance with the mobile radio telephone system to provide the portable computer with a means for duplex communications via the first communications channel with a mobile radio telecommunications network.
3. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 2, wherein the transmitter of said first pair and the receiver of said second pair

are coupled to the first data processor unit and the receiver of said first pair and the transmitter of the said second pair are connected to the said mobile radio telecommunications network.

4. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding Claim, wherein the second communicator comprises a transmitter and a receiver, said receiver being coupled to said first data processor unit embodied within the portable computer, and said transmitter acting in combination with said receiver in accordance with the DAB-like system to provide the second communications channel.

5. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding claim, wherein the first data processor unit is an applications program interface processor, which operates to exchange data between applications programs operating on the portable computer and the first and second communicators.

6. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding claim, wherein the first communicator operates in accordance with a cellular mobile radio system to provide the first digital communications link.

7. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 6, wherein the cellular

mobile radio system is a Global System for Mobiles (GSM)-like system.

8. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 7, wherein the first communications channel is provided by a Short Message Service of the GSM-like system.

9. Apparatus for providing a wireless communications link to a portable computer as claimed in any of Claims 1 to 5, wherein the first communicator operates in accordance with a cordless telephone system such as a Digital Enhanced Cordless Telephone (DECT)-like system.

10. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding claim, further comprising a first interface unit arranged to communicate with a second telecommunications network, a second interface unit arranged to communicate with a DAB-like transmitter, a third interface unit arranged to communicate with a third telecommunications network, and a second data processor unit being connected to the first, second and third interface units and which second data processor unit operates to exchange data between first, second and third interface units.

11. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 10, wherein the second

telecommunications network is a public switch telephone network, which public switch telephone network is further arranged to communicate with the mobile radio telecommunications network.

12. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 10, wherein the second telecommunications network is a private fixed telecommunications network, which private fixed telephone network is further arranged to communicate with the mobile radio telecommunications network.

13. Apparatus for providing a wireless communications link to a portable computer as claimed in Claims 10, 11 or 12, wherein the third telecommunications network acts in combination with said mobile radio network and said second telecommunications networks to form an internet, or a part thereof.

14. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 13, wherein the third interface unit is an internet service provider.

15. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding Claim, wherein the first communicator further comprises a first protocol processor which operates in accordance with a first data link layer protocol to establish a communications link via the first digital communications channel with the first interface unit.

16. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 15, wherein the first data link layer protocol is a point-to-point protocol.

17. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 16, wherein the point-to-point protocol is an Internet Standard 51 Point-to-Point Protocol.

18. Apparatus for providing a wireless communications link to a portable computer as claimed in Claims 15, 16 or 17, wherein the first communicator further comprises a second protocol processor, which communicates with the first protocol processor and operates in accordance with a second data link layer protocol to establish an internet link with the second data processor unit.

19. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 18, wherein the second data link layer protocol comprises an Internet Protocol which operates in combination with an Internet Message Control Protocol.

---

20. Apparatus for providing a wireless communications link to a portable computer as claimed in Claims 17 or 18, wherein the first communicator further comprises a third protocol processor, which communicates with the second protocol processor and operates in

accordance with a transport protocol to establish communications with another computer connected to the internet.

21. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 20, wherein the transport protocol is a User Datagram Protocol.

22. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 20, wherein the transport protocol is a Transport Control Protocol.

23. Apparatus for providing a wireless communications link to a portable computer as claimed in any preceding Claim, further comprising an initialisation means which operates to establish said first and second communications channels.

24. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 23, wherein the initialisation means is embodied within the portable computer.

25. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 23, wherein the initialisation means is embodied within the internet service provider.

---

26. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 23, wherein the

initialisation means is embodied within the mobile radio telecommunications network.

27. Apparatus for providing a wireless communications link to a portable computer as claimed in Claim 23, wherein the initialisation means is embodied within the said another computer.

28. Apparatus for providing a wireless communications link to a portable computer substantially as hereinbefore described with reference to the accompanying drawings.

---





Application No: GB 9705123.9  
Claims searched: 1 to 28

Examiner: Mr Jared Stokes  
Date of search: 23 April 1997

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.O): H4L (LDG, LDLX, LDSX)  
H4P (PPEC)

Int Cl (Ed.6): H04Q (7/20, 7/22, 7/32)  
H04L (29/06)

Other: H04Q (7/20, 7/22, 7/22S3, 7/32D)  
H04L (29/06 + all lower marks) - searched on-line since manual search, in the  
light of citations already found, not justified.

### Documents considered to be relevant:

| Category | Identity of document and relevant passage            | Relevant to claims |
|----------|--|--------------------|
| X        | EP 0 700 225 A2 (AT&T) Whole document, esp. abstract | 1 at least         |
| Y        | EP 0 629 071 A1 (AT&T) Figure 1, abstract            | 1 at least         |
| Y        | WO95 /34153 A1 (Hughes) Page 22 lines 3-12, fig.1    | 1 at least         |
| A        | US 5 537 399 (Philips) See column 2 lines 4-22       | -                  |

|   |   |   |  |
|---|---|---|--|
| X | Document indicating lack of novelty or inventive step   | A | Document indicating technological background and/or state of the art.  |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention.          |
| & | Member of the same patent family  | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |



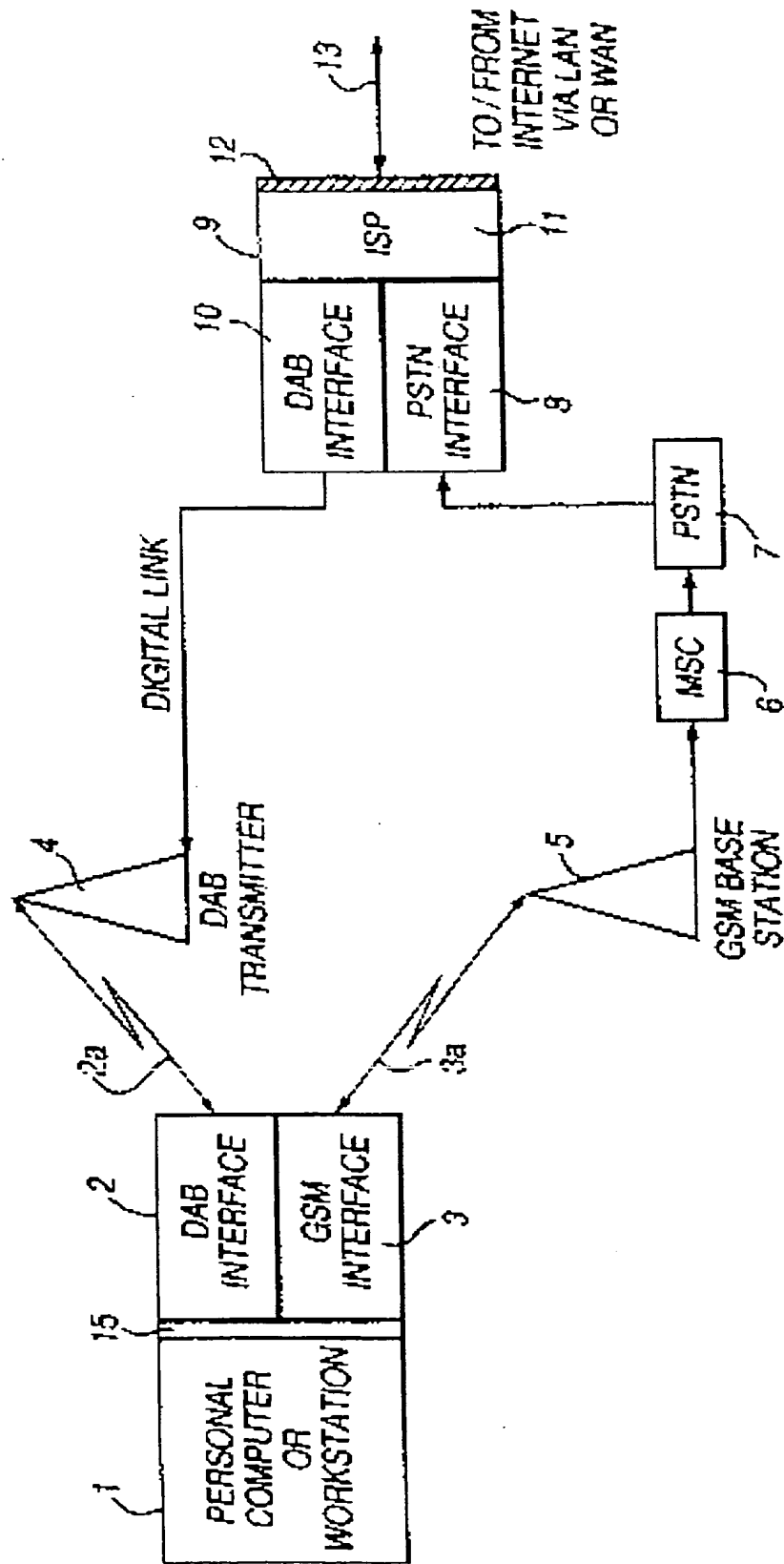


Fig. 1

2/2

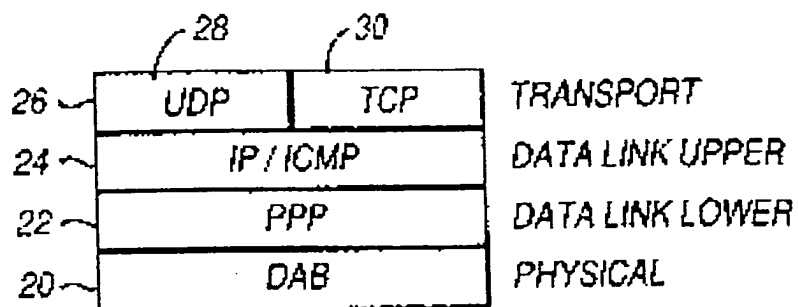


Fig. 2a

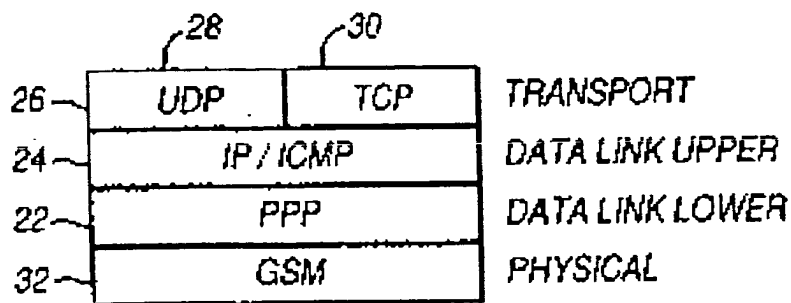


Fig. 2b

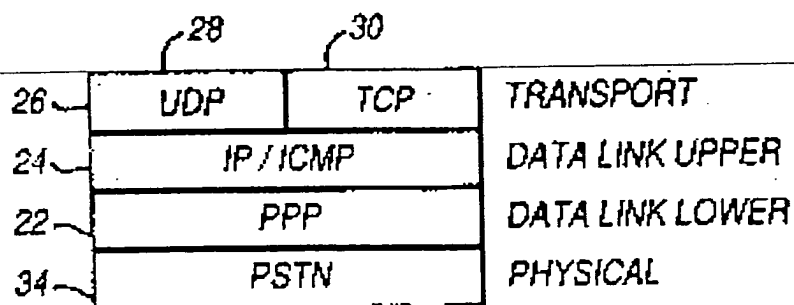


Fig. 2c